A91854

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 July 2001 (19.07.2001)

PCT

(10) International Publication Number
WO 01/51785 A1

(51) International Patent Classification[7]: F02B 27/00, 25/20 // 25/14, 33/04

(21) International Application Number: PCT/SE00/00059

(22) International Filing Date: 14 January 2000 (14.01.2000)

(25) Filing Language: Swedish

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: AKTIEBOLAGET ELECTROLUX [SE/SE]; S-105 45 Stockholm (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: CARLSSON, Bo [SE/SE]; Frejvägen 4, S-448 32 Floda (SE). STRÖM, Hans [SE/SE]; Bräcke 14003, S-442 60 Kode (SE).

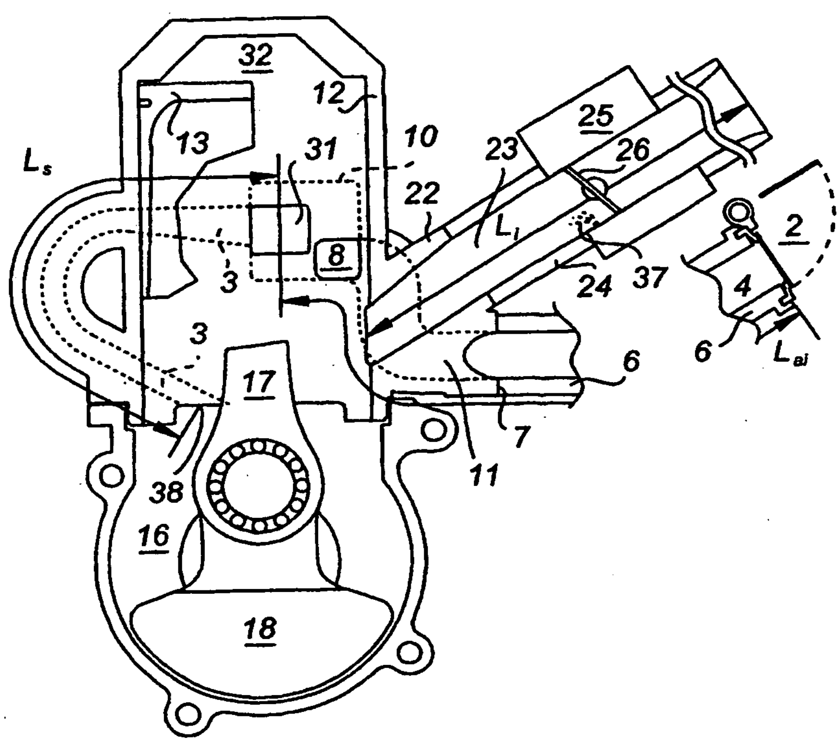
(74) Agents: ANDERSSON, Lars et al.; AB Electrolux, Husqvarna AB, S-433 81 Jonsered (SE).

(81) Designated States *(national)*: AE, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: TWO-STROKE INTERNAL COMBUSTION ENGINE



(57) Abstract: Crankcase scavenged two-stroke internal combustion engine (1), in which at least one piston ported air passage, with length L_{ai}, is arranged between an air inlet (2) and each scavenging port (31, 31') of a number of transfer ducts (3, 3'), with length L_s, from the scavenging port to the crankcase. The air passage is arranged from an air inlet

[Continued on next page]

WO 01/51785 A1

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(2) equipped with a restriction valve (4), controlled by at least one engine parameter, for instance the carburettor throttle control. The air inlet extends via at least one connecting duct (6, 6') to at least one connecting port (8, 8') in the engine's cylinder wall (12). The connecting port (8, 8') is arranged so that it in connection with piston positions at the top dead centre is connected with flow paths (10, 10') embodied in the piston (13), which extend to the upper part of a number of transfer ducts (3, 3'). Each flow path of the piston is arranged so that the air supply is given an essentially equally long period, counted as crank angle or time, as the engine's inlet (22-25), and the length of the inlet into which fuel is added, Li, is greater than 0,6 times the total length of the piston ported air passage L_{ai} and the length of the transfer duct L_s, i.e. 0,6 x (L_{ai}+L_s) but smaller than 1,4 times the same length, i.e. 1,4 x (L_{ai} + L_s).

TWO-STROKE INTERNAL COMBUSTION ENGINE

Technical field

The subject invention relates to a two-stroke crankcase scavenged internal combustion engine, in which a piston ported air passage is arranged between an air inlet and the upper part of a number of transfer ducts. Fresh air is added at the top of the transfer ducts and is intended to serve as a buffer against the air/fuel mixture below. Mainly this buffer is lost out into the exhaust outlet during the scavenging process. The fuel consumption and the exhaust emissions are thereby reduced. The engine is foremost intended for a handheld working tool.

Background of the invention

Combustion engines of the above mentioned kind are known since long time. They reduce the fuel consumption and exhaust emissions, but it is difficult to control the air/fuel ratio in such an engine.

US 5,425,346 shows an engine with a somewhat different design than the above mentioned. In this case, channels are arranged in the piston of the engine, which at specific piston positions are aligned with ducts arranged in the cylinder. Fresh air, as shown in figure 7, or exhaust gases can thereby be added to the upper part of the transfer ducts. This only happens at the specific piston positions where the ducts in the piston and the cylinder are aligned. This happens both when the piston moves downwards and when the piston moves upwards far away from the top dead centre. To avoid unwanted flow in the wrong direction in the latter case, check valves are arranged at the inlet to the upper part of the transfer ducts. This type of check valves, usually called reed valves, has however a number of disadvantages. They have frequently a tendency to come into resonant oscillations and can have difficulties to cope

with the high rotational speeds that many two-stroke engines can reach. Besides, it results in added cost and increased number of engine components. The amount of fresh air added is varied by means of a variable inlet, i.e. an inlet that can be advanced or retarded in the work cycle. This is however a very complicated solution.

The international patent application W098/57053 shows a few different embodiments of an engine where air is supplied to the transfer ducts via L-shaped or T-shaped recesses in the piston. Thus, there are no check valves. In all embodiments the piston recess has, where it meets the respective transfer duct, a very limited height, which is essentially equal to the height of the actual transfer port. A consequence of this embodiment is that the passage for the air delivery through the piston to the transfer port is opened significantly later than the passage for the air/fuel mixture to the crankcase is opened by the piston. The period for the air supply is consequently significantly shorter than the period for the supply of air/fuel mixture, where the period can be counted as crank angle or time. This could complicate the control of the total air-fuel ratio of the engine. This also means that the amount of air that can be delivered to the transfer duct is significantly limited, since the underpressure driving this additional air has decreased a lot, because the inlet port has already been open during a certain period of time when the air supply is opened. This implies that both the period and the driving force for the air supply are small. Furthermore, the flow resistance in the L-shaped and the T-shaped ducts as shown becomes relatively high, partly because the cross section of the duct is small close to the transfer port and partly because of the sharp bend created by the L-shape or T-shape. In all, this contributes to increasing the flow resistance and to reducing the amount of air that can be delivered to the transfer ducts, which reduces the possibilities to reduce the fuel consumption and the exhaust emissions by means of this arrangement.

The purpose of the invention

The purpose of the subject invention is to significantly reduce the above mentioned problems and to achieve advantages in many respects.

Summary of the invention

The above mentioned purpose is achieved by a two-stroke combustion engine in accordance with the invention showing the characteristics of the appended patent claims.

The combustion engine in accordance with the invention is thus essentially characterized in that the air passage is arranged from an air inlet equipped with restriction valves, controlled by at least one engine parameter, e.g. the carburettor throttle control, the mentioned air inlet is via at least one connecting duct channelled to at least one connecting port in the cylinder wall of the engine, which is arranged so that it, in connection with piston positions at the top dead centre, is connected with flow paths embodied in the piston, which extend to the upper part of a number of transfer ducts, and the flow paths are so arranged that the recess in the piston that meets the respective transfer duct's port is so arranged that the supply of air is given an essentially equally long period, counted as crank angle or time, as the engine's inlet, and the length of the inlet 22-25 into which fuel is added, L_i, is greater than 0,6 times the total length of the piston ported air passage L_{ai} and the length of the transfer duct L_s, i.e. 0,6 x (L_{ai} + L_s) but smaller than 1,4 times the same length, i.e. 1,4 x (L_{ai} + L_s).

By adapting the length of the ducts leading the air to the crankcase in relation to the length of the inlet duct, the control of the engine can be simplified. By adapting these two duct systems in relation to each other the flow in each system will vary concurrently with the flow in the other system. In this manner a carburettor in the inlet system could supply the correct amount of fuel to the engine irrespective of load variations etc.

Because at least one connecting port in the engine's cylinder wall is arranged so that it in connection with piston positions at the top dead centre is connected with flow paths embodied in the piston, the supply of fresh air to the upper part of the transfer ducts can be arranged entirely without check valves. This can take place because at piston positions at or near the top dead centre there is an underpressure in the transfer duct in relation to the ambient air. Thus a piston ported air passage without check valves can be arranged, which is a big advantage. Because the air supply has a very long period, a lot of air can be delivered, so that a very high exhaust emissions reduction effect can be achieved. Control is applied by means of a restriction valve in the air inlet, controlled by at least one engine parameter. Such control is of a significantly less complicated design than a variable inlet. The air inlet has preferably two connecting ports, which in one embodiment are so located that the piston is covering them at its bottom dead centre. The restriction valve can suitably be controlled by the engine speed, alone or in combination with another engine parameter. These and other characteristics and advantages are clarified in the detailed description of the different embodiments, supported by the enclosed drawing figures.

Brief description of the drawing

The invention will be described in closer detail in the following by means of various embodiments thereof with reference to the accompanying drawing figures. For parts that are symmetrically located on the engine, the part on the one side has been given a numeric designation while the part on the opposite side has been given the same designation but with a '-symbol. In the drawings the parts with a '-symbol are located above the plane of the paper and are therefore not visible.

Figure 1 shows a side view of an engine according to the invention. The cylinder is shown in a cross section, as well as the piston, which is shown at the top dead centre.

Figure 2 shows a corresponding conventional engine. In order to explain the invention a conceivable partition wall is placed in the engine's inlet duct, as shown by dashed lines.

Description of embodiments

In figure 1, numeral reference 1 designates an internal combustion engine according to the invention. It is of two-stroke type and has transfer ducts 3, 3'. The latter is not visible since it is located above the plane of the paper. The engine has a cylinder 15 and a crankcase 16, a piston 13 with a connecting rod 17 and a crank mechanism 18. Furthermore, the engine has an inlet tube 22 with an inlet port 23 and an, to the inlet tube connected, intermediate section 24, which in turn connects to a carburettor 25 with a throttle valve 26. Usually the carburettor connects to an inlet muffler with a filter. These are not shown for the sake of clarity. The same applies for the exhaust port, the exhaust duct and the muffler of the engine. These are totally conventional and located on the opposite side of the cylinder compared to the inlet. The piston has a plane upper side without any steps or similar, so that it co-operates equally with the cylinder ports wherever they are located around the periphery. The height of the engine body is therefore approximately unchanged in comparison with a conventional engine. The transfer ducts 3 and 3' have ports 31 and 31' in the engine's cylinder wall 12. The engine has a combustion chamber 32 with a spark plug, which is not shown. All of this is conventional and is therefore not further commented.

What is special is that an air inlet 2 equipped with a restriction valve 4 is arranged so that fresh air can be supplied to the cylinder. The air inlet 2 has a connecting duct 6 channelled to the cylinder, which is equipped with an outer connecting port 7. By connecting port is from now on meant the port of the connection on the inside of the cylinder, while its port on the outside of the cylinder is called the outer connecting port. The air inlet 2 suitably connects to an inlet muffler with a filter, so that cleaned fresh air is

taken in. If the requirements are lower, this is of course not necessary. The inlet muffler is not shown for the sake of clarity.

A connecting duct 6 is thus connected to an outer connecting port 7. This is an advantage. At or after this port the duct divides into two branches 11, 11' leading to a connecting port 8, 8' each. These are located symmetrically and the parts with a '-symbol are as mentioned lying above the plane of the paper. The outer connecting port 7 is thus located under the inlet tube 22, which means a number of advantages such as lower air temperature and a better utilizing of space for a handheld working tool, which usually has a fuel tank.

However, the connecting port 7 could also be located above the inlet tube 22, which then is directed more horizontally. Wherever they are located two outer connecting ports 7, 7' could be used. They could then also be located on each side of the inlet tube 22.

Flow paths 10, 10' are arranged in the piston so that they, in connection with piston positions at the top dead centre, connect the respective connecting port 8, 8' to the upper part of the transfer ducts 3, 3'. The flow paths 10, 10' are made by means of local recesses in the piston. The piston is simply manufactured, usually cast, with these local recesses.

Usually the connecting ports 8, 8' are so located in the axial direction of the cylinder that the piston covers them when it is located at its bottom dead centre. Thereby exhaust gases cannot penetrate into the connecting port and further towards an eventual air filter. But it is also possible that the connecting ports 8, 8' are located so high up that they to some part are open when the piston is located at its bottom dead centre. This is adapted so that a desirable amount of exhaust gases will be supplied into the connecting duct 6. A highly located connecting port could also reduce the flow resistance of air at the changeover from connecting port to scavenging port 31.

The period of air supply from the connecting ports 8, 8' to the scavenging port 31, 31' is very important and is to a great extent determined by the flow paths in the piston, i.e. the recess 10, 10' in the piston.

Preferably the upper edge of the recess is located so high that it when the piston is moving upwards from the bottom dead centre reaches up to the lower edge of the respective port 31, 31' at the same time as the lower edge of the piston reaches up to the lower edge of the inlet port. Thereby the air connection between the connecting ports 8, 8' and the scavenging ports 31, 31' is opened at the same time as the inlet is opened. When the piston moves down again after being at the top dead centre then also the air connection and the inlet will be shut off at the same time and thus be given an essentially equally long period. It is desirable that the inlet period and the air period are essentially equally long. Preferably the air period should be 90 % - 110 % of the inlet period. Because, both these periods are limited by the maximum period during which the pressure is low enough in the crankcase to enable a maximal inflow. Both periods are preferably maximised and equally long. The position of the upper edge of the recess 10, 10' will thus determine how early the recess will come into contact with each scavenging port 31, 31' respectively. Consequently, preferably the recess 10, 10' in the piston that meets each port 31, 31' respectively, has an axial height locally at this port that is greater than 1.5 times the height of the respective scavenging port, but preferably greater than 2 times the height of the scavenging port. This provided that the port has a normal height so that the upper side of the piston, when located in its bottom dead centre, is level with the underside of the scavenging port, or is protruding only a few millimetres.

The recess is preferably downwards shaped in such a way that the connection between the recess 10, 10' and the connecting port 8, 8' is maximised, since it reduces the flow resistance. This means that when the piston is located at its top dead centre, the recess 10, 10' preferably reaches so far down that it does not cover the connecting port 8, 8' at all, as shown in

figure 1. As a whole, this means that the recess 10, 10' in the piston that meets each connecting port 8, 8' respectively, has an axial height locally at this port that is greater than 1.5 times the height of the respective connecting port, but preferably greater than 2 times the height of the connecting port.

The relative location of the connecting port 8, 8' and the scavenging port 31, 31' can be varied considerably provided that the ports are shifted sideways, i.e. in the cylinder's tangential direction, as shown in figure 1. Figure 1 illustrates a case where the connecting port and the scavenging port 31, 31' have an axial overlap, i.e. that the upper edge of each connecting port respectively is located as high or higher in the cylinder's axial direction as the lower edge of each scavenging port respectively. One advantage is that the two ports are more aligned with each other in an arrangement of this kind, which reduces the flow resistance when air is being transported from the connecting port to the scavenging port. Consequently, more air can be transported, which can enhance the positive effects of this arrangement, i.e. reduced fuel consumption and exhaust emissions. For many two-stroke engines, the piston's upper side is level with the lower edge of the exhaust outlet and the lower edge of the scavenging port, when the piston is at its bottom dead centre. However, it is also quite common for the piston to extend a millimetre or a few above the scavenging port's lower edge. If the lower edge of the scavenging port is further lowered, an even greater axial overlap will be created between the connecting port and scavenging port. When air is supplied to the scavenging duct, the flow resistance is now reduced, both due to that the ports are more level with each other and also due to the greater surface area of the scavenging port.

The invention contains two important principles for adapting or tuning of these both duct systems. One principle is that the supply of air to the transfer duct is opened essentially at the same time as the inlet of the air/fuel-mixture to the crankcase is opened. This is described earlier in closer detail. The other principle is that the lengths in both of the systems are being tuned in

relation to each other. This principle can be best explained by studying figure 2 showing a corresponding conventional engine without any air supply system for the transfer duct. In this conventional engine the partition wall 36 is missing, as shown by dashed lines in the inlet duct. Accordingly, the conventional engine has only one inlet tube where the whole intake flow passes through the carburettor and affects the fuel flow 37 and thereby a desired ratio of air/fuel is achieved since the carburettor will supply the engine with fuel in proportion to the amount of inlet air. Consequently, when a separate system according to figure 1 is arranged in order to supply the engine with air, only air will pass through the connecting duct 6 while air/fuel-mixture will pass through the inlet 22-25. Thereby only a smaller part of the engine's amount of inlet air will pass through the carburettor and the flow of fresh air in the connecting duct 6 will not affect the fuel flow 37 in the inlet. However it is still possible, owing to a special tuning of the both duct systems in the engine, to give them the same dynamic tuning. This is simplest understandable by imagining an arrangement of a longitudinal partition wall 36 in the conventional engine according to figure 2. The partition wall 36 divides the inlet tube into two parts without changing their characteristic features. All the amount of fuel 37 is supplied to the one part of the tube. The flow in these both parts of the tube, which is divided by the partition wall 36, will vary in proportion to each other. In case the one flow is doubled also the other flow is doubled etc. The basic principle is that the characteristic features of the inlet tube will not be changed because of the fact that the area is separated by a longitudinal partition wall. Now, if this principle is transferred to figure 1, then we have an inlet system, i.e. the inlet 22-25, to which all the fuel 37 is supplied. This has a length L_i, which is marked in the figure. This length can be increased or decreased, which is marked with the cut off close to the outer end of the inlet tube. The other inlet system for fresh air extends from the air inlet 2 and all the way up to the transfer duct's 3 mouth 38 in the crankcase. This comprises two parts. The first part, which is designated L_{ai},

extends from the inlet 2 and up to the mouth of the scavenging port 31. It thus extends through the conn...ting duct 6 and the connecting branch 11 and through the connecting port 8 and then through the piston recess 10 up to the scavenging port 31. Obviously this is on the condition that the piston is located at a position close to the top dead centre for which the piston recess 10 connects the both ports 8 and 31. The length of the transfer duct L_s, from the scavenging port 31 to the mouth 38, represents the last part of the air inlet system. The total length for this system is thus $L_{ai} + L_s$. The connecting duct 6 is illustrated in a divided mode in order to point out that its length can be varied. For, in order to shorten the length $L_{ai} + L_s$ it might be suitable to place the air inlet 2 close to the outer connecting port 7. In case the length of L_i is made essentially as long as the length of $L_{ai} + L_s$ an unchanged ratio of air/fuel can be achieved at different ranges of speed and load even if all the fuel is being supplied into the normal inlet. In principle you could say that you take the lower part of the inlet duct according to figure 2 and instead place it as an air duct from the inlet 2 to the outlet 38 in the crankcase. However, naturally the design of the engine is also affected by a number of practical wishes of different nature that makes it difficult to achieve exactly the same relation between the lengths. It is desirable that the length of the inlet, into which fuel is added, L_i, is greater than 0.6 times the total length of the piston ported air passage L_{ai} and the length of the transfer duct L_s, i.e. 0,6 times $(L_{ai} + L_s)$ but smaller than 1.4 times the same length, i.e. 1,4 times $(L_{ai} + L_s)$. Preferably the length L_i is greater than 0,8 times the total length of the piston ported air passage L_{ai} and the length of the transfer duct L_s, i.e. 0,8 times $(L_{ai} + L_s)$ but smaller than 1.2 times the same length, i.e. 1,2 times $(L_{ai} + L_s)$.

It is important that the recess 10 in the piston, as well as the ports 8 and 31, are so arranged that the flow resistance at the changeover of air between the ports becomes so small that the tuning is not being disturbed. This tuning takes place primarily when both the valves 26 and 4 are fully open.

When the valves are partly closed different conditions will take place more and more.

The relation between the flow in the both systems, at full throttle operation, i.e. unrestricted running depends on the cross section area for each flow path respectively. Preferably this is made as regular as possible, but in case this is not possible the cross section area might be regarded as an average value. Consequently, in the analogy in figure 2 this corresponds to where the partition wall 36 is located. In order to achieve a high degree of efficiency of the arrangement it is preferable that a great amount of air is added through the air supply system with inlet 2. Preferably the cross section area for the air flow path, with length $L_{ai} + L_s$, is 100-200 % of the cross section area for the inlet, with length L_i, so that the amount of inlet air, at full throttle operation, represents 50-67 % of the total amount of inlet gases. Preferably the cross section area for the air flow path, with length $L_{ai} + L_s$, is arranged so that it is 120-180 % of the cross section area for the inlet, with length L_i, so that the amount of inlet air, at full throttle operation, represents 55-64 % of the total amount of inlet gases. The invention has a number of advantages. A normal standard carburettor can be used mounted in the inlet duct. And now since the cross section area of the inlet duct has been halved, or overbearingly halved, a smaller standard carburettor can be used which will reduce the price, volume and cost for it. The length of the both inlet systems can be determined at the manufacturing procedure and will not be affected by the environment or aging and thereby the air/fuel ratio will not be affected by these facts. By this simple arrangement a controlled ratio of air/fuel has been achieved for the range of speed and load. Compared with a conventional engine only a simple type of restriction valve 4 has been added in order to regulate the amount of air in the air supply system. This valve should be completely or almost completely closed at idle and then, when the throttle valve opens, it will gradually open more and more. For example, it could be actuated by a link that transfers the desirable movement from the throttle valve.

CLAIMS

1. Crankcase scavenged two-stroke internal combustion engine (1), in which at least one piston ported air passage, with length L_{ai}, is arranged between an air inlet (2) and each scavenging port (31, 31') respectively of a number of transfer ducts (3, 3') with length L_s, from the scavenging port to the crankcase, c h a r a c t e r i z e d in that the air passage is arranged from an air inlet (2) equipped with a restriction valve (4) controlled by at least one engine parameter, for example the carburettor throttle control, the air inlet extends via at least one connecting duct (6, 6') to at least one connecting port (8, 8') in the cylinder wall (12) of the engine, which is arranged so that it, in connection with piston positions at the top dead centre, is connected with flow paths (10, 10') embodied in the piston (13), which extend to the upper part of a number of transfer ducts (3, 3'), and each flow path in the piston is so arranged that the recess (10,10') in the piston that meets the respective scavenging port (31,31') is so arranged that the air supply is given an essentially equally long period, counted as crank angle or time, as the engine inlet (22-25), and the length of the inlet into which fuel is added, L_i, is greater than 0,6 times the total length of the piston ported air passage L_{ai} and the length of the transfer duct L_s, i.e. $0{,}6 \times (L_{ai} + L_s)$ but smaller than 1,4 times the same length, i.e. $1{,}4 \times (L_{ai} + L_s)$.

2. Crankcase scavenged internal combustion engine (1) according to claim 1, c h a r a c t e r i z e d in that the length of the inlet into which fuel is added, L_i, is greater than 0,8 times the total length of the piston ported air passage L_{ai}, and the length of the transfer duct L_s, i.e. $0{,}8 \times (L_{ai} + L_s)$ but smaller than 1,2 times the same length. i.e. $1{,}2 \times (L_{ai} + L_s)$.

3. Crankcase scavenged internal combustion engine (1) according to any one of the claims 1-2, c h a r a c t e r i z e d in that the period for air supply is greater than 90 % of the inlet period but smaller than 110 % of the inlet period.

4. Crankcase scavenged internal combustion engine (1) in accordance with any of the preceding claims, c h a r a c t e r i z e d in that the recess (10, 10') in the piston that meets the respective port (31, 31') of the transfer ducts has an axial height locally at this port that is greater than 1.5 times the height of the respective scavenging port (31, 31'), preferably greater than 2 times the height of the scavenging port.

5. Crankcase scavenged internal combustion engine (1) in accordance with any of the preceding claims, c h a r a c t e r i z e d in that the air inlet (2) has at least two connecting ports (8, 8') in the engine's cylinder wall (12).

6. Crankcase scavenged internal combustion engine (1) in accordance with any of the preceding claims, c h a r a c t e r i z e d in that the connecting port(s) (8, 8') in the engine's cylinder wall (12) are so located that the piston (13) covers them when it is located at its bottom dead centre.

7. Crankcase scavenged internal combustion engine (1) in accordance with any one of the claims 1-5, c h a r a c t e r i z e d in that the connecting port(s) (8, 8') in the engine's cylinder wall (12) are so located that the piston (13) does not cover them when it is located at its bottom dead centre, but exhaust gases from the cylinder can penetrate into the air inlet.

8. Crankcase scavenged internal combustion engine (1) in accordance with any of the preceding claims, c h a r a c t e r i z e d in that the flow paths (10, 10') in the piston at least partly are arranged in the form of at least one recess (10, 10') in the periphery of the piston.

9. Crankcase scavenged internal combustion engine (1) in accordance with any of the preceding claims, c h a r a c t e r i z e d in that the cross section area for the air flow path, with length $L_{ai} + L_s$, is 100-200 % of the cross section area for the inlet, with length L_i, so that the amount of inlet air, at full throttle operation, represents 50-67 % of the total amount of inlet gases.

10. Crankcase scavenged internal combustion engine (1) in accordance with any of the preceding claims, c h a r a c t e r i z e d in that the cross section area for the air flow path, with length $L_{ai} + L_s$, is 120-180 % of the cross section area for the inlet, with length L_i, so that the amount of inlet air, at full throttle operation, represents 55-64 % of the total amount of inlet gases.

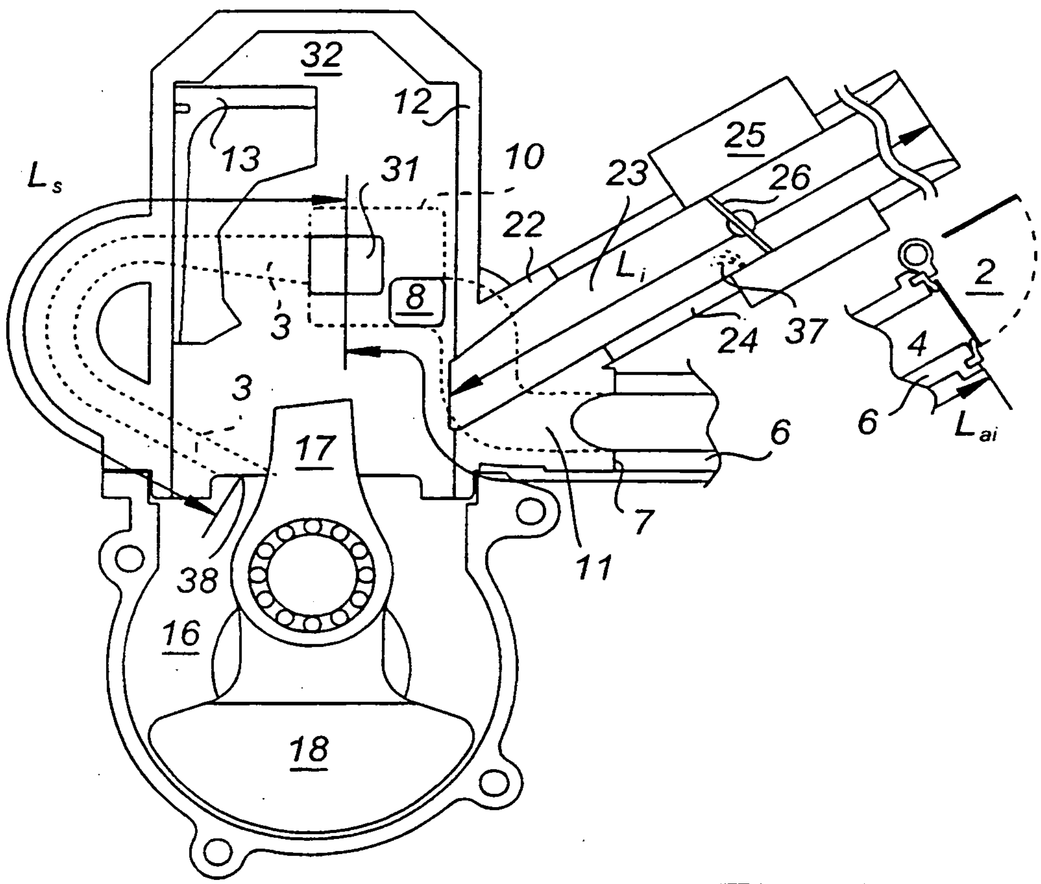


Fig. 1

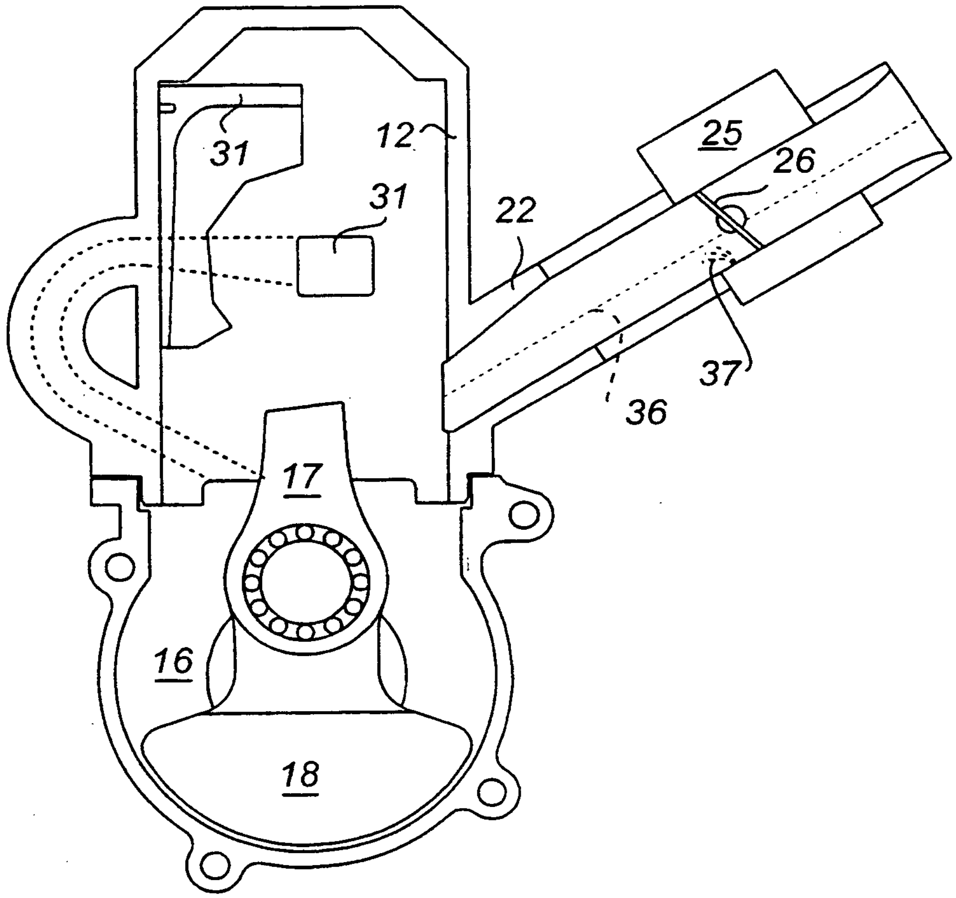


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/00059

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F02B 27/00, F02B 25/20 // F02B 25/14, F02B 33/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0337768 A2 (TALT, R.J.), 18 October 1989 (18.10.89) --	1-10
A	DE 19857738 A1 (KERN, H.), 1 July 1999 (01.07.99) --	1-10
A	WO 9857053 A1 (KOMTATSU ZENOAH CO. ET AL), 17 December 1998 (17.12.98) --	1-10
A	US 5425346 A (N.S. MAVINAHALLY), 20 June 1995 (20.06.95) --	1-10

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 Sept 2000	29 -09- 2000

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Björn Kallstenius / MRo Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/00059

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4248185 A (E. JAULMES), 3 February 1981 (03.02.81) -- --------	1-10

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/08/00

International application No.
PCT/SE 00/00059

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0337768 A2	18/10/89	GB 8808855 D	00/00/00
DE 19857738 A1	01/07/99	NONE	
WO 9857053 A1	17/12/98	AU 7550298 A	30/12/98
		EP 0992660 A	12/04/00
US 5425346 A	20/06/95	NONE	
US 4248185 A	03/02/81	FR 2431605 A,B	15/02/80